ENVIRONMENTAL SENSITIVITY INDEX: BRISTOL BAY SUBAREA, ALASKA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the Bristol Bay Subarea, which includes marine and coastal areas of Bristol Bay and part of the southern Alaska Peninsula. This area extends from directly south of Goodnews Bay to slightly north of Port Seniavan along the Bristol Bay side of the Alaska Peninsula, as well as the Pacific Ocean side of the Alaska Peninsula from Cape Providence to Kupreanof Peninsula. ESI maps are a compilation of information from three main categories: shoreline habitats, sensitive biological resources, and human-use resources.

The individual map pages in this atlas are divided according to the U.S. Geological Survey (USGS) topographic quadrangle index. Grey-scale scanned images of these maps are used as a backdrop for each map page in the atlas.

SHORELINE HABITAT MAPPING

ESI maps for the region were created using sources and methods described below. Shoreline habitats were mapped during overflights and ground surveys conducted by experienced coastal geologists. The shoreline of Bristol Bay (Goodnews Bay to slightly north of Port Seniavan) was originally mapped from 24 July to 28 August 1981 during the fieldwork for the previous Bristol Bay ESI maps. The shoreline of the southern coast of the Alaska Peninsula (from Cape Providence to Kupreanof Peninsula) was originally mapped from 27 July to 26 August 1985 during the fieldwork for the previous Southern Alaska Peninsula ESI maps. During these overflights, the shoreline types were recorded on then-current 1:63,360-scale USGS topographic maps. Only large-scale modifications to the shoreline were noted on the maps (and only those observed during the 1981 and 1985 overflights). Because of the complexity of the shoreline, multiple habitats were often described for each shoreline segment. Salt marshes, while extensive in Bristol Bay, were seldom mapped as polygonal features because of the difficulty determining their landward extent. However, many of the tidal flats were mapped as polygons.

To determine the sensitivity of a particular intertidal shoreline habitat, the following factors are integrated:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affect the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. The potential for biological injury, and ease of cleanup of spilled oil are also important factors in the ESI ranking. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, have low biological activity and rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for the Bristol Bay Subarea ordered by increasing sensitivity to spilled oil.

1A) Exposed Rocky Shores
2A) Exposed Wave-cut Platforms in Bedrock, Mud, or Clay
3A) Fine- to Medium-grained Sand Beaches
4) Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
7) Exposed Tidal Flats
8A) Sheltered Rocky Shores and Sheltered Scarps in Mud and Clay
8E) Peat Shorelines
9A) Sheltered Tidal Flats
10A) Salt- and Brackish-water Marsh

Each of the shoreline habitats is described on pages 8-12, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

Biological information presented in this atlas was collected, compiled, and reviewed with the assistance of biologists and resource managers from the U.S. Fish and Wildlife Service (USFWS), Alaska Department of Fish and Game (ADF&G), U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) and National Marine Mammal Laboratory (NMML), Alaska Department of Natural Resources (ADNR), Alaska Department of Commercial and Economic Development (DCED), and Alaska Division of Governmental Coordination (DGC). Information collected and depicted on the maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Six major categories of biological resources are included in this atlas: terrestrial mammals, marine mammals, birds, fish, invertebrates, and benthic marine habitats.

Polygons, points, and arcs represent the spatial distribution of biological resources on the maps. Associated with each of these representations is an icon depicting the types of species that are present. Species have been divided into groups and subgroups, based on their behavior, morphology, taxonomic classification, and spill vulnerability and sensitivity. The icons below reflect this grouping scheme. Please note that benthic marine habitats are displayed on the maps using "simplified-wetland" patterns rather than the hatched patterns used for the other species groups, and icons are used only in limited areas where the habitats are in high concentrations (see legend). For all other species, the groups are color coded, and different icons represent the subgroups:

BIRDS

- Diving Birds
- Gulls and Terns
- Raptors
- Seabirds
- Shorebirds
- Waterfowl

TERRESTRIAL MAMMALS

- Bears

MARINE MAMMALS

- Dolphins
- Pinnipeds
- Sea Otters
- Whales

FISH

- Fish

INVERTEBRATES

- Bivalves
- Crabs
- Shrimp

The polygon color and pattern are generally the same for all species in each major group (e.g., birds are green), and match the icon colors. Also associated with each biological polygon or point feature on the map is a Resources at Risk identification number (RAR#), located under each icon or group of icons. The RAR# references a table on the reverse side of the map with a complete list of species associated with the polygon, point, or line feature, and the state and federal protected status as threatened, endangered (T&E), or species of special concern (C), concentration, seasonality, and life-history information for each species.

There are some species that are found throughout general geographical areas or habitat types on certain maps. Displaying the polygons for these species would cover large areas or would obscure the shoreline, ESI classification, or other biological features, making the maps very difficult to read. Thus, species that occur over the majority of certain geographic areas or habitats are often identified in a small box on the maps which states that they are "Present in ..." (e.g., "Present in Bristol Bay" or "Present in Pacific Ocean"). The use of this strategy is implemented on a map per map basis, depending on the location, size, and number of polygons present on each map.

TERRESTRIAL MAMMALS

Brown bear concentration areas around certain rivers, lagoons, and bays are depicted in the Bristol Bay atlas. Locations of brown bears were based on concentration areas depicted in Alaska Department of Fish and Game (ADF&G) Most Environmentally Sensitive Area (MESA) data and areas described by resource experts. Brown bears are likely to occur in and near rivers, streams, and some lakes particularly when salmon are running. Other mammals potentially occurring in the area that were not mapped include: caribou, reindeer, moose, wolf, fox, beaver, mink, river otter, dall sheep, and others. These species were not mapped due to their relatively wide distributions and a lack of information regarding particular concentration areas, and/or the unlikelihood of impact during coastal and marine oil spills due to their use of more upland and inland habitats.

Terrestrial mammal areas are displayed on the maps as polygons with a brown-hatched pattern. A brown icon with a bear silhouette is used to indicate the presence of brown bears and is associated with all polygons containing this species.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table, the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. Most important bear-use areas indicated by the MESA data and agency staff were described as

"high" in the concentration field. The seasonality for each species or resource is shown in the next twelve columns, corresponding to the months of the year. If a species is present at a location in a particular month, an "X" is placed in the month column.

MARINE MAMMALS

Marine mammals depicted in the Bristol Bay Subarea atlas include: beluga, fin (federally endangered), gray, humpback (federally and state endangered), killer and minke whales; Dall's and harbor porpoises; spotted, ringed, and harbor seals; Steller sea lions (federally endangered and state species of special concern); sea otters, and walruses. Nearshore concentration areas, most environmentally sensitive areas (MESAs), haul-out sites (seals, sea lions, walruses), and migration routes are specifically indicated on the maps. All marine mammal occurrences are depicted as polygons. Many marine mammal species are important subsistence resources for Alaska Natives.

Information on the geographic distribution of marine mammals was gathered from personal interviews with resource experts, digital survey data provided by ADF&G, USFWS, and NMFS, hardcopy maps, published reports, and books. We did not attempt to show the complete distribution of any of these species, as they occur throughout a larger range than the areas depicted.

The species that were mapped are described below.

Ringed seal – Ringed seals are associated with moving pack ice and stable shorefast ice for pupping and breeding. Pups are born in March and April, and juveniles may be found in open water. Pups are extremely sensitive to oil contamination for the first 6 to 8 weeks because their primary insulation is from fur and not from a thick layer of blubber. Molting occurs on shorefast ice and on large flat ice floes from May to July. Most ringed seals occur along the edge of the permanent ice pack during the summer.

Bearded seal – Bearded seals are typically associated with the moving pack ice-edge, as well as in association with leads, flaws, and polynyas. Some seals migrate north in the summer, while others remain in ice-free Bering Sea waters. Pupping occurs between March and May, and molting occurs in May and June.

Spotted and harbor seals – Spotted seals are associated with the sea ice-front during the winter and while breeding, pupping, and molting. Pupping occurs in April and May, and molting occurs from May until July. Spotted seals occur nearshore and haul-out on land during ice-free months. Harbor seals are resident in coastal waters of the study area. Important haul-outs include: Seal Islands, Port Heiden, Cinder River, Egegik Bay, and Ugashik Bay. Peak haul-out occurs from June to October, and pupping occurs between late May and early July. Use of haul-outs may also occur earlier in the spring. Because these species are difficult to tell apart during surveys in areas where their ranges overlap, most haul-outs and concentration areas are described as having "seals" present, rather than identifying the individual species.

Walrus – Walruses haul out on secluded shores and islands during the ice-free months. Important haul-outs in Bristol Bay include the Walrus Islands, Cape Pierce, and Cape Newenham. Major winter breeding concentration areas occur south and southwest of St. Lawrence Island and in the vicinity of Nunivak Island, Kuskokwim Bay, and Bristol Bay. Feeding concentrations also occur in Bristol Bay during the ice-free period and likely correspond with productive clam beds.

Steller sea lion (federally endangered) – Steller sea lions may be present along the south side of the Alaska Peninsula and throughout northwestern Bristol Bay. Haul-outs and the Walrus Island rookery are identified on the maps.

Beluga whale – Beluga whales are present in Bristol Bay from late March until freeze-up and concentrate in the Naknek, Kvichak, Snake, Igushik, Wood, and Nushagak Rivers feeding on smelt and outmigrating sockeye salmon smolt. Calving occurs between June and August in Kvichak and Nushagak Bays.

Other cetaceans – Gray whales are commonly seen migrating along the Alaska Peninsula during spring. Harbor and Dall's porpoises, killer whales, and minke whales are present in the summer in Bristol Bay and year-round in the Pacific Ocean. Humpback and fin whales are present only on the Pacific Ocean side of the Alaska Peninsula in the summer.

Sea otter – Sea otters are more common along the south side of the Alaska Peninsula than the north side in this study area. Concentration areas include Kujulik and Hallo Bays. Sea otters may also be present in Port Heiden and Egegik Bay on the north side of the Alaska Peninsula depending on ice conditions. This species is a candidate for ESA (Endangered Species Act) listing in this area.

Expert contacts for marine mammals are: Lloyd Lowry and Kathy Frost (retired ADF&G, Fairbanks), 907/455-6885, Lori Quakenbush (ADF&G, Fairbanks), 907/459-7214, and Gay Sheffield (ADF&G, Fairbanks), 907/459-7248; for cetaceans is Barb Mahoney (NMFS, Anchorage), 907/271-3448; for sea lions are Lowell Fritz and John Sease (NMFS, Seattle), 206/526-4246; for seals is Dave Withrow (NMFS, Seattle), 206/526-4019, Bob Small (ADF&G, Juneau), 907/465-6167, and Scott Wolfe (ADF&G, Anchorage), 907/267-2393; for walruses is Joel Garlich-Miller (USFWS, Anchorage), 907/786-3820; for sea otters are Doug Burn (USFWS, Anchorage), 907/786-3807 and Angie Doroff (USFWS, Anchorage) 907/786-3803. For information on subsistence use of marine mammals contact Ted Krieg (ADF&G, Dillingham), 907/842-5925.

Marine mammal areas are displayed on the maps as polygons with a brown-hatched pattern. A brown icon with a whale, dolphin, pinniped, or sea otter silhouette is used to indicate the presence of marine mammals and is associated with all polygons and points containing these resources. In cases where multiple resource types occupy the same polygon (such as marine mammals and fish), a black-hatched, multi-group pattern is used rather than a brown-hatched polygon.

The RAR# under an icon (or icon group) references a table on the reverse side of the map. In this table the first column gives the species name. The next column provides an estimate of the concentration of the species at the site. Concentration is represented using descriptive terms or using numeric values estimated in reports or by resource experts. Steller sea lion haul-out concentration estimates (numeric values) were based on survey data provided by NOAA NMML and Togiak NWR staff. Walrus haul-out usage estimates were based on surveys conducted by Togiak NWR staff (see McDonald, 2002). Walrus mating and feeding area concentrations ("high") were provided by USFWS staff and were based on field studies conducted by agency staff and Fay, Ray, and Kibal'chich (1984) and Fay and Lowry (1981). Beluga whale concentration estimates ("high" and numeric estimates) were provided by NMFS and ADF&G staff and were derived from survey data and reports. Seal concentration estimates (ranges, e.g. < 10, 10s, 100s, 1000s,) were provided by ADF&G and NMML staff and were based on survey data. Sea otter concentration estimates ("high") were based on survey data provided by USFWS staff. In some cases, concentration values have not been used if the information is not known. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns corresponding to the months of the year. If a species is present at a location in a particular month an "X" is placed in the month column. The final columns list the time periods for sensitive life-history activities such as pupping for seals and calving for beluga whales.

BIRDS

Birds depicted in this atlas are divided into several subgroups based on taxonomy, morphology, behavior, and oil spill vulnerability and sensitivity. The species table lists all birds included on the maps sorted by subgroup. These species are included either because of their likelihood of direct or indirect impact by an oil spill or similar incident, their general rarity or imperilment, or their special protection status as threatened or endangered.

The atlas includes seabird nesting colonies; raptor concentration areas; waterfowl and diving bird nesting, migratory staging, and molting areas; and shorebird staging and nesting areas. Nesting sites are of particular concern due to high concentrations of birds in adjacent waters, risk of contamination of eggs and young by oiled adults and prey, and the potential for disturbance from response activities. Waterfowl are particularly vulnerable to the effects of spilled oil during the molting period when birds are flightless and often concentrated in large numbers on the water. The molting period varies by species but occurs during the summer and fall months.

Seabird nesting sites – Locations are shown where seabirds have been documented as nesting. Birds are in the vicinity of colonies from April through October, and they may be rafting and feeding in large concentrations in offshore waters. Information on nesting colony size (number of birds present) is included in tables on the reverse side of the maps. This information was derived from a frequently updated USFWS database.

Eagle nests and feeding concentration areas – Nesting locations for bald eagles are shown. These data are a compilation of surveys conducted by Togiak NWR (survey year 2003), Alaska Peninsula and Becharof NWR (survey year 2000), and data housed by ADF&G in Juneau (multiple survey years). Exact nest sites may vary from year to year. Locations are also shown where bald eagles have been documented as being present in high numbers feeding along rivers and in bays. Information on raptor feeding areas was gathered during interviews with Alaska Peninsula/Becharof NWR staff and USFWS MBM (Migratory Bird Management) staff and compiled from ADF&G MESA data.

Waterfowl nesting areas – Locations are shown where waterfowl are nesting as determined by aerial surveys conducted in 1993-1994. The nesting season varies by species, but birds are generally present from

April through October. The data were provided by USFWS Migratory Bird Management (MBM) and consisted of separate ArcView coverages for each nesting species. Within each separate species coverage, density "contours" or polygons were created by MBM staff identifying the number of nesting birds present per square kilometer. Not all nesting species are shown. USFWS staff helped to determine which species are of highest conservation concern in the region based on several factors, including: those species for which a large percentage of the population expected to nest in the subarea, those species which are rare or imperiled, or those species which nest in high densities nearshore. This subset of species was included on the maps in order to highlight areas of primary concern during an oil spill.

Waterfowl migratory staging and molting areas – Concentration areas are shown for migratory waterfowl in bays, estuaries, rivers, lakes, and coastal areas. Geographic and concentration information was provided by ADF&G MESA data, NWR staff, and USFWS Migratory Bird Management biologists and was based on published reports, digitally generated maps, 5 years of spring and fall aerial survey data, and expert knowledge of the area. Numeric and descriptive concentrations were based on conversations with biologists with extensive experience in conducting bird surveys in Alaska. The term "high" often refer to nearshore or estuarine zones of high use for particular species during certain times of year. Numeric concentrations shown for sea ducks typically refer to peak single day counts recorded during aerial surveys over the last five years. Peak counts were used because biologists assumed that even peak counts may grossly underestimate the number of birds potentially congregating in an area during a spill event that spans several days or longer. The spatial extent and number of birds using "high-use zones" varies from year to year, and resource experts should be contacted in case of a spill regarding recent counts. Waterfowl are particularly vulnerable to the effects of spilled oil during the molting period, which varies by species, but occurs during the summer and fall months.

Migratory shorebird stopover and nesting areas – Areas where large concentrations of shorebirds occur annually during the spring, summer, and/or autumn months were mapped. Information on the locations of these areas and concentrations of particular species were based on information provided by a USGS report that included a compilation of survey data from various sources over many years and detailed descriptions of major staging and nesting areas. Alaska Peninsula/Becharof NWR staff provided ArcView shapefiles of the geographic extent of the key areas. Togiak NWR staff provided additional recent data in report form for important areas on the refuge. Numeric concentrations shown for shorebirds vary based on the type of survey conducted. These counts may either refer to the total number of birds potentially using an area over the entire migratory season, or a peak single day count. In either case, large numbers of shorebirds may concentrate for short periods and would be vulnerable during a spill event that spans several days or longer.

Expert contacts are: for seabirds, Shawn Stephensen (USFWS, Anchorage), 907/786-3691, and David Irons (USFWS, Anchorage), 907/786-3376; for shorebirds, Bob Gill (USGS, Anchorage), 907/786-3514; for waterfowl, Bill Larned (USFWS, Soldotna), 907/262-9863 ext. 224, Chris Dau (USFWS, Anchorage), 907/786-3908, and Mark Fink (ADF&G, Anchorage), 907/267-2338; for loons, Joel Schmutz (USGS, Anchorage), 907/786-3518; for endangered/threatened species, Charla Sterne (USFWS, Anchorage), 907/271-2781, for digital waterfowl nesting data, Bob Platte (USFWS, Anchorage), 907/786-3565; for Togiak National Wildlife Refuge species, Rob MacDonald (USFWS, Dillingham), 907/842-1966 ext. 314; for Alaska Peninsula/Becharof National Wildlife Refuge Species, Susan Savage (USFWS, King Salmon), 907/246-1205, and Dick Sellers (ADF&G, retired, King Salmon); and for bald eagles, Donna Dewhurst (USFWS, Anchorage), 907/786-3499.

Birds are shown on the maps as polygons with a green-hatched pattern. Seabird nesting colonies are shown as green points. Users should be aware that seabirds may be feeding and rafting in nearshore and offshore areas in the vicinity and up to several miles away from their nests. During an oil spill, the seabird experts listed above should be contacted for information on current seabird rafting locations.

The RAR# under an icon (or icon group) references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. See the descriptions of the species groups mapped and the sources of data used (above) for information on how numeric concentration values and descriptive terms were generated. In some cases, concentration values have not been used if the information was not available. Note that concentration should not be interpreted as the "level of concern" or "importance" associated with a certain site or particular resource.

The seasonality for each species or resource is shown in the next twelve columns corresponding to months of the year. If a species or resource is present at a location in a particular month an "X" is placed in the month column. The last three columns denote the migratory, nesting, and molting time-periods for each species.

FISH

Finfish depicted in this atlas include selected marine, estuarine, freshwater, and anadromous species. Species of commercial, subsistence, recreational, ecological, and/or conservation interest are emphasized.

Pacific herring and capelin spawning areas – Documented intertidal and subtidal herring and capelin spawning areas were mapped. Geographic information was provided by ADF&G resource experts and published ADF&G MESA digital data. Spawning occurs during the late spring and summer months. Adult herring form large spawning groups and deposit their eggs onto eelgrass, kelp, and other suitable substrate in nearshore areas. Capelin spawn on gravel beaches during full moons in June. Because spawning occurs in shallow water, both adults and eggs are susceptible to exposure to floating slicks and oil remobilized from adjacent intertidal areas. Fish eggs are susceptible to mortality, reduced hatching success, and an overall decrease in the percent of viable hatch during spills. Herring and capelin are important diet items for marine fishes, mammals, and birds. The herring fishery is very important commercially in Bristol Bay. An average of 120,000-130,000 tons of herring has been harvested annually from Bristol Bay in recent years. Herring spawn on kelp is an important subsistence resource.

Anadromous fish – Wild stocks of anadromous fish are major components to the marine ecosystem of Bristol Bay. Chinook, chum, coho, pink, and sockeye salmon, and Dolly Varden are present in the area. The six major river systems in Bristol Bay (Nushagak, Kvichak, Naknek, Egegik, Ugashik, Meshik, and Chignik) support the world's largest sockeye salmon fishery. The streams shown have been classified by ADF&G as anadromous streams, and this listing is frequently updated. When adult fish return to their natal streams to spawn between March and October, they tend to concentrate at the stream mouths prior to moving upstream. Most spawning beds are well upstream, beyond the limit of tidal excursions that could carry oil slicks inland. Juvenile salmon may concentrate in shallow, nearshore habitats, particularly during March through June and are likely to be impacted during a spill.

Marine/estuarine fish – General distributions of nearshore species, particularly those that are important prey species for marine mammals and harvested for subsistence, were mapped in nearshore waters. Resource experts from ADF&G provided information on the geographic distribution and seasonal presences of these species. General distributions of several species of groundfish (e.g., halibut, walleye pollack, yellowfin sole, etc.) were mapped using information provided by NMFS staff. More detailed information on the geographic extent of these species was not available at the time these maps were created. Contact the NMFS Essential Fish Habitat program for updated information. It was difficult to thoroughly depict all estuarine and shallow water rearing habitats throughout the study area due to the magnitude of nearshore data for other species, but it is important to note that these habitats are significant for juvenile rearing and ADF&G staff should be contacted in the event of oil spill.

Please contact the resource experts listed below for additional information on any of these or other species that may occur in the area.

Expert contacts for finfish are: Matt Eagleton (NMFS, Anchorage), 907/271-5006; Paul Salamone (ADF&G, Anchorage), 907/267-2135; Tim Sands (ADF&G, Dillingham), 907/842-5227; Lowell Fair, (ADF&G, Anchorage), 907/486-1825, and Mike Ruccio (ADF&G, Kodiak), 907/486-1845. For information on subsistence use of fish contact Ted Krieg (ADF&G, Dillingham) 907/842-5925.

Fish are shown on the maps as polygons with a blue-hatched pattern. Anadromous streams are shown as blue arcs. In areas where arcs occur in large water bodies (e.g., wide streams or rivers), it can be assumed that the fish may occur in the entire width of the water body, beyond the width of the arc. In cases where multiple resource types occupy the same polygon (such as fish and invertebrates), a black-hatched, multi-group pattern is used rather than a blue-hatched polygon. A blue icon with a fish silhouette is used to indicate the presence of fish. This icon is associated with all polygons or arcs containing fish.

The RAR# under an icon (or icon group) references a table on the reverse side of the map. In this table, the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Descriptive terms such as "high" were used to describe certain species based on the recommendations of resource experts.

Concentration values were not used when no information was available.

Seasonality for each species or resource is shown in the next twelve columns corresponding to the months of the year. If a species or resource is present at a location in a particular month an "X" is placed in the month column. The last columns denote different life-history time-periods for fish, including spawning, eggs, larvae, juveniles, and adults.

INVERTEBRATES

Invertebrate species of commercial, subsistence, recreational, ecological, and/or conservation interest are emphasized in this atlas and include: crabs, scallops, shrimp, and clams. Invertebrate distributions are based on information gathered from published reports and meetings with Togiak NWR and NMFS staff.

Expert contacts for invertebrates are: Pat Walsh and Rob McDonald (USFWS, Dillingham), 907/842-1063, Matt Eagleton (NMFS, Anchorage), 907/271-6354, and Mike Ruccio (ADF&G, Kodiak), 907/486-1845. For information on subsistence use of invertebrates contact Ted Krieg (ADF&G, Dillingham) 907/842-5925.

Invertebrates are shown on the maps as polygons with an orange-hatched pattern. An orange icon with a crab, shrimp, or bivalve silhouette is used to indicate the presence of these species. The icons are associated with all polygons or point features containing invertebrates.

The RAR# under an icon (or icon group) on the maps references a table on the reverse side of the map. In this table the first column contains the species common name. The second column indicates whether the species is listed as threatened (T), endangered (E), or special concern (C) on either the state (S) and/or federal (F) lists. The next column provides an estimate of the concentration of the species at the site. Descriptive terms ("high") were used for some species based on information provided by ADF&G and USFWS staff. Concentration values were not used when no information was available.

The seasonality for each species or resource is shown in the next twelve columns corresponding to the months of the year. If a species or resource is present at a location in a particular month an "X" is placed in the month column. The last columns denote different life-history time-periods for invertebrates, including spawning, eggs, larvae, juveniles, and adults.

BENTHIC MARINE HABITATS

The two types of benthic marine habitats mapped for the Bristol Bay Subarea atlas are eelgrass and kelp. Locations of these resources were based largely on expert opinion. Both eelgrass and kelp are important habitats for Pacific herring spawning.

Expert contacts for eelgrass and kelp are: Tim Sands (ADF&G, Anchorage), 907/486-1825, Pat Walsh (Togiak NWR, Dillingham), 907/842-1063, and Donna Dewhurst (USFWS, Anchorage), 907/786-3499.

Eelgrass and kelp are depicted on the maps using two different purple "simplified-wetland" patterns for the different vegetation types. An icon and an RAR# is used only when kelp is found in high concentrations.

SEA ICE

Figure 1 displays the average "five-tenths ice concentration" boundaries for December, January, February, March, and April in Bristol Bay (LaBelle et al., 1983). "Five-tenths ice concentration" signifies the ice concentration above which ice breaking vessels are needed for navigation, meaning that approximately 50 percent of the ocean surface in the area is ice covered. Four- to six-tenths coverage is considered to be "open pack ice". In the figure, the ocean surface on the hatched side of the boundary lines, (i.e., north of Egegik Bay on December 15) has a sea-ice concentration of five-tenths or greater, indicating that ice coverage is greater than 50 percent, and may be considered to be "close pack ice" (seven- to eight-tenths coverage), or "very close pack ice" (ten-tenths coverage). On the un-hatched sides of the boundary lines (i.e. south of Egegik Bay on December 15), the ice concentration is five-tenths or less, indicating less than 50 percent coverage, and may be considered to be "very open pack ice" (one- to three-tenths coverage). As the winter progresses, the five-tenths ice concentration boundary lines move farther and south. Ice typically begins forming in sheltered lagoons in October/November and recedes northward in March/April. Sea ice does not form on the Pacific Ocean side of the Alaska Peninsula.

Shorefast ice and pack ice are very important habitats for some marine mammals species. It is important to note that some species present in nearshore waters during the winter (e.g. ringed and bearded seals) are utilizing the shorefast and pack ice habitat, while species present in the same areas during the summer (e.g. salmon, beluga whales) are using open water habitats.

It is important to note that ice conditions can be vary greatly from year to year, and that that information provided in the figures and text are based on multi-year averages and specific studies. For real-time ice conditions, refer to the National Weather Service Alaska region website at www.arh.noaa.gov and select "Ice Desk" under Specialty Areas.

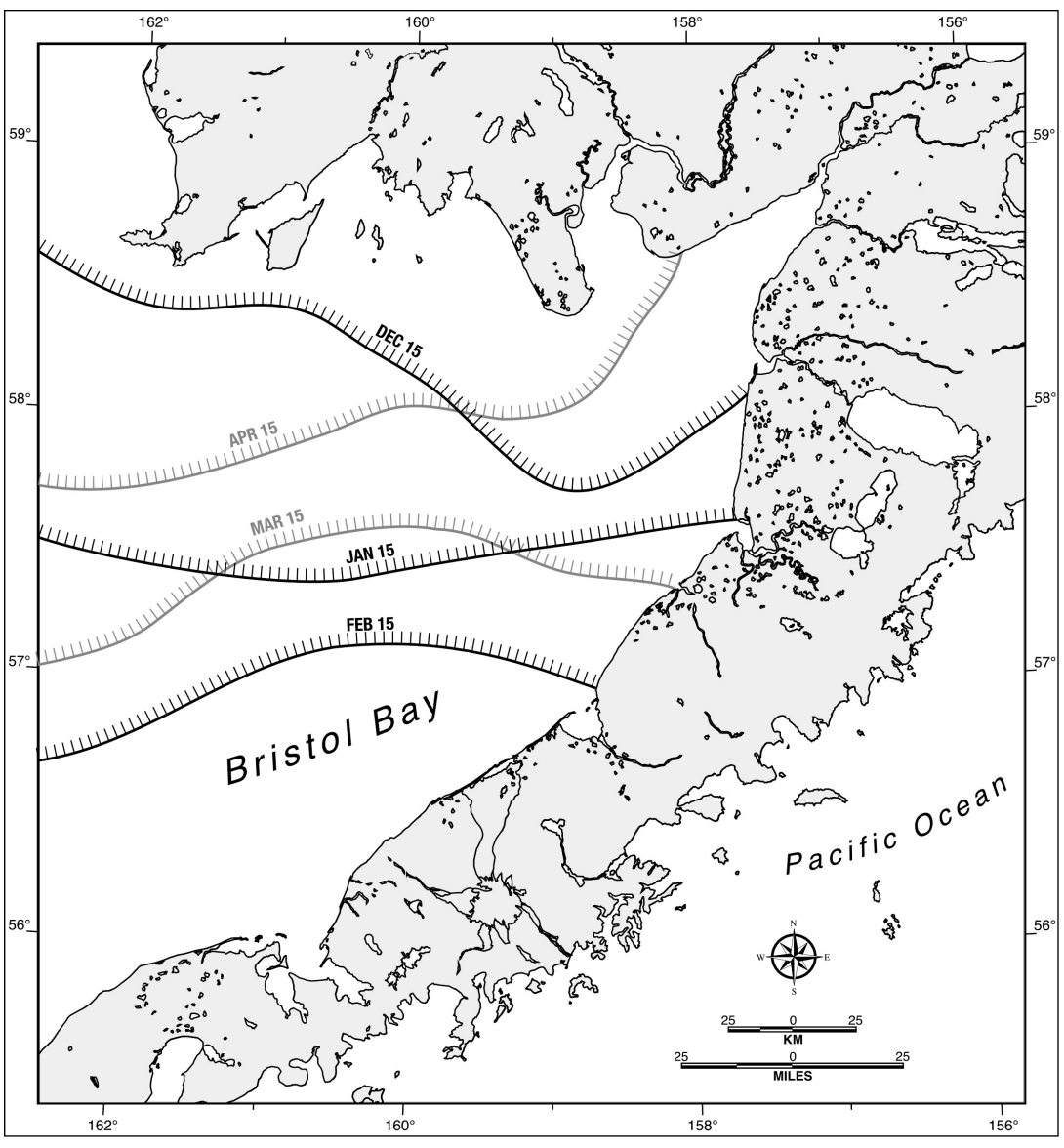
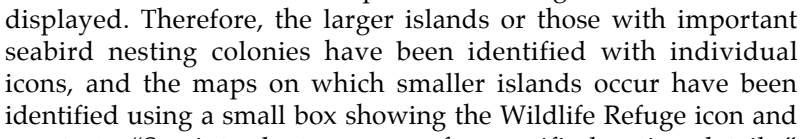


FIGURE 1. Five-tenths ice concentration boundaries for December, January, February, March, and April. Lines represent median position of five-tenths ice concentration boundaries. On average, sea water on the hatched side of a line has five-tenths ice coverage or greater on the date shown, and sea water on the unhatched side of a line has five-tenths ice coverage or less. Figure adapted from LaBelle et al. (1983).

HUMAN-USE RESOURCES

Management areas such as wildlife refuges, national parks, wilderness areas, and critical habitats are mapped as polygons, with the boundaries indicated as a black dot-dash line with the corresponding icon placed near the center of the polygon. Where the feature is a known point location (e.g. airport), the exact location is shown as a small black dot and a leader line is drawn from it to the icon.



Airport: Locations of airports, airfields, landing strips, helipads etc., whether they are manned or unmanned, are shown as point features. Information on the locations of these features was gathered from a 1995 ADNR digital database and from USGS topographic quadrangles.

Critical Habitat: These are areas managed or regulated by ADF&G or NMFS as critical habitat for the protection of fish and wildlife. Critical Habitat boundaries were extracted from an ADNR (2000) "Administrative Large Parcel Boundaries" coverage for ADF&G lands and from NMFS for Stellar sea lion Designated Critical Habitat.

Lands managed by the National Park Service: Lands managed by the National Park Service depicted in this atlas include: National Parks, Preserves, Monuments, Wilderness Areas, and Wild Rivers. National Park boundaries were extracted from a NPS (2002) "Alaska National Park Boundaries" coverage.

Wildlife Refuges*: Areas managed by the USFWS as National Wildlife Refuges and by ADF&G as State Game Sanctuaries. Refuge and sanctuary boundaries were extracted from an ADNR (2000) "Administrative Large Parcel Boundaries" coverage.

* **The Alaska Maritime National Wildlife Refuge** encompasses more than 2,400 islands, headlands, rocks, islets, spires, and reefs off the Alaskan coast. The refuge stretches from Cape Lisburne on the Chukchi Sea to the tip of the Aleutians. Due to the large number of very small islands, rocks, islets, etc. included in the refuge, not all of them could be individually identified using icons due to the scale of the maps and the large amount of data displayed. Therefore, the larger islands or those with important seabird nesting colonies have been identified with individual icons, and the maps on which smaller islands occur have been identified using a small box showing the Wildlife Refuge icon and a note to "See introductory pages for specific location details." Please refer to the digital data for the exact boundaries of the refuge or contact the Refuge Manager at 907/235-6546.

GEOGRAPHIC INFORMATION SYSTEM

The entire atlas product is stored in digital form in a Geographic Information System (GIS) as spatial data layers and associated databases. Format for the data varies depending on the type of information or features for which the data are being stored.

Under separate cover is a metadata document that details the data dictionary, processing techniques, data lineage, and other descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Refer to the metadata file for a full explanation of the data and its structure.

SHORELINE CLASSIFICATIONS

The ESI shoreline habitat classification is stored as lines and polygons with associated attributes. In many cases, a shoreline may have two or three different classifications. These multiple classifications are represented on the maps by double and triple line patterns and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification. In addition to the line features, exposed wave-cut platforms (ESI = 2A) and tidal flats (ESI = 7, ESI = 9A) are also stored as polygons.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are stored as polygons, points, or arcs. Associated with each feature is a unique identification number that is linked to a series of data tables that further identify the resources. The main biological resource table consists of a list of species identification numbers for each site, the concentration of each species at each site, and identification codes for seasonality and source information. This data table is linked to other tables that describe the seasonality and life-history time-periods for each species (at month resolution) for the specified map feature. Other data tables linked to the first table include: the species identification table that includes common and scientific names; the species status table that gives information for state and/or federal threatened or endangered listings; and the source database that provides source metadata at the feature-species level (specific sources are listed for each species occurring at each mapped feature in the biology coverages).

HUMAN-USE FEATURES

Human-use features are represented as lines, points, or polygons. The resource name, the owner/manager, a contact person, and phone number are included in the database for management areas when available. All metadata sources are documented at the feature level.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication concerning resources depicted in the atlas.

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The biological and human-use data included on the maps were provided by numerous individuals, agencies, and organizations. U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, NOAA National Marine Fisheries Service and National Marine Mammal Laboratory, U.S. Geological Survey, and Alaska Department of Natural Resources staff from several divisions and programs contributed a vast amount of information to this effort, including first-hand expertise, publications, reports, maps, and data. Other agencies, organizations, and groups contributing to data development and review included: Bureau of Land Management, Alaska Department of Commercial and Economic Development, Alaska Division of Governmental Coordination, Alaska Regional Response Team, and The Nature Conservancy. Specific individuals and references used directly as source material for this atlas are detailed in the metadata report that accompanies the digital data set.

At Research Planning, Inc. (RPI) of Columbia, South Carolina, numerous scientific, GIS, and graphics staff were involved with different phases of the project. The biological and human-use data were collected, compiled onto basemaps, and edited by Christine Lord. Jacqueline Michel and Miles O. Hayes conducted the original ESI shoreline classification. E. Lee Diveley, Vermell Simon Pyatt, Jon Whitlock, and Katie Born entered, processed, and produced the GIS data and hardcopy atlas under the supervision of Mark White, GIS Director, and Chris Locke. Jeff Dahlin assisted with processing of GIS data. Joe Holmes conducted the graphic art production. Mandie Minton and Wendy Early assisted with final atlas production.

APPROPRIATE USE OF ATLAS AND DATA

This atlas and the associated database were developed to provide summary information on sensitive natural and human-use resources for the purposes of oil and chemical spill planning and response. Although the atlas and database should be very useful for other environmental and natural resource planning purposes, it should not be used in place of data held by the USFWS, USGS, ADF&G, NMFS, NMML or other agencies. Likewise, information contained in the atlas and database cannot be used in place of consultations with natural and cultural resource agencies, or in place of field surveys. Also, this atlas should not be used for navigation.

SPECIES LIST

Common Name	Species Name
MARINE MAMMALS	
DOLPHIN	
Dall's porpoise	*Phocoenoides dalli*
Harbor porpoise	*Phocoena phocoena*
PINNIPED	
Bearded seal	*Erignathus barbatus*
Ringed seal	*Pusa hispida*
Seals	-
Spotted seal	*Phoca largha*
Steller (Northern) sea lion	*Eumetopias jubatus*
Walrus	*Odobenus rosmarus*
SEA_OTTER	
Sea otter	*Enhydra lutris*
WHALE	
Beluga whale	*Delphinapterus leucas*
Fin whale	*Balaenoptera physalus*
Gray whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeangliae*
Killer whale	*Orcinus orca*
Minke whale	*Balaenoptera acutorostrata*
TERRESTRIAL MAMMALS	
BEAR	
Brown bear	*Ursus arctos*
BIRDS	
ALCID	
Ancient murrelet	*Synthliboramphus antiquus*
Common murre	*Uria aalge*
Crested auklet	*Aethia cristatella*
Horned puffin	*Fratercula corniculata*
Kittlitz's murrelet	*Brachyramphus brevirostris*
Least auklet	*Aethia pusilla*
Murre	*Uria sp.*
Parakeet auklet	*Aethia psittacula*
Pigeon guillemot	*Cepphus columba*
Rhinoceros auklet	*Cerorhinca monocerata*
Thick-billed murre	*Uria lomvia*
Tufted puffin	*Fratercula cirrhata*
DIVING	
Cormorant	*Phalacrocorax sp.*
Double-crested cormorant	*Phalacrocorax auritus*
Pacific loon	*Gavia pacifica*
Pelagic cormorant	*Phalacrocorax pelagicus*
Red-faced cormorant	*Phalacrocorax urile*
Red-throated loon	*Gavia stellata*
GULL_TERN	
Aleutian tern	*Sterna aleutica*
Arctic tern	*Sterna paradisaea*
Glaucous-winged gull	*Larus glaucescens*
Gulls	
Herring gull	*Larus argentatus*
Mew gull	*Larus canus*
PELAGIC	
Black-legged kittiwake	*Rissa tridactyla*
Fork-tailed storm-petrel	*Oceanodroma furcata*
Leach's storm-petrel	*Oceanodroma leucorhoa*
RAPTOR	
Bald eagle	*Haliaeetus leucocephalus*
SHOREBIRD	
Bar-tailed godwit	*Limosa lapponica*
Black oystercatcher	*Haematopus bachmani*
Black turnstone	*Arenaria melanocephala*
Black-bellied plover	*Pluvialis squatarola*
Bristle-thighed curlew	*Numenius tahitiensis*
Common snipe	*Gallinago gallinago*
Dunlin	*Calidris alpina*
Greater yellowlegs	*Tringa melanoleuca*
Least sandpiper	*Calidris minutilla*
Long-billed dowitcher	*Limnodromus scolopaceus*
Marbled godwit	*Limosa fedoa*
Pacific golden-plover	*Pluvialis fulva*
Pectoral sandpiper	*Calidris melanotos*
Red knot	*Calidris canutus*
Red phalarope	*Phalaropus fulicaria*
Red-necked phalarope	*Phalaropus lobatus*
Rock sandpiper	*Calidris ptilocnemis*
Ruddy turnstone	*Arenaria interpres*
Sanderling	*Calidris alba*
Semipalmated plover	*Charadrius semipalmatus*
Sharp-tailed sandpiper	*Calidris acuminata*
Shorebirds	-
Short-billed dowitcher	*Limnodromus griseus*

Common Name	Species Name
BIRDS, cont.	
Spotted sandpiper	*Actitis macularia*
Western sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
WATERFOWL	
Black scoter	*Melanitta nigra*
Brant	*Branta bernicla*
Canada goose	*Branta canadensis*
Common eider	*Somateria mollissima*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Dabbling ducks	-
Ducks	-
Emperor goose	*Chen canagica*
Geese	-
Greater white-fronted goose	*Anser albifrons*
Harlequin duck	*Histrionicus histrionicus*
King eider	*Somateria spectabilis*
Long-tailed duck	*Clangula hyemalis*
Northern pintail	*Anas acuta*
Red-breasted merganser	*Mergus serrator*
Scaup	*Aythya spp.*
Sea ducks	-
Steller's eider	*Polysticta stelleri*
Surf scoter	*Melanitta perspicillata*
Tundra swan	*Cygnus columbianus*
Waterfowl	-
White-winged scoter	*Melanitta fusca*
FISH	
FISH	
Alaska plaice	*Pleuronectes quadrituberculatus*
Arrowtooth flounder	*Atheresthes stomias*
Atka mackerel	*Pleurogrammus monopterygius*
Capelin	*Mallotus villosus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon (dog)	*Oncorhynchus keta*
Coho salmon (silver)	*Oncorhynchus kisutch*
Dolly varden	*Salvelinus malma*
Dover sole	*Microstomus pacificus*
Flathead sole	*Hippoglossoides elassodon*
Pacific cod	*Gadus macrocephalus*
Pacific halibut	*Hippoglossus stenolepis*
Pacific herring	*Clupea pallasi*
Pink salmon (humpy)	*Oncorhynchus gorbuscha*
Rainbow smelt	*Osmerus mordax*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Rex sole	*Errex zachirus*
Rock sole	*Lepidopsetta bilineata*
Rougheye rockfish	*Sebastes aleutianus*
Sablefish (blackcod)	*Anoplopoma fimbria*
Saffron cod	*Eleginus gracilis*
Sculpin	*Cottidae*
Shortraker rockfish	*Sebastes borealis*
Sockeye salmon (red)	*Oncorhynchus nerka*
Starry flounder	*Platichthys stellatus*
Walleye pollock	*Theragra chalcogramma*
Whitefish	-
Yellowfin sole	*Limanda aspera*
HABITATS	
KELP	
Kelp	-
EELGRASS	
Eelgrass	*Zostera marina*
INVERTEBRATES	
BIVALVE	
Alaska razor clam	*Siliqua alta*
Butter clam	*Saxidomus giganteus*
Clams	-
Nuttall cockle	*Clinocardium nuttallii*
Weathervane scallop	*Patinopectin caurinus*
CRAB	
Red king crab	*Paralithodes camtschaticus*
Tanner crab	*Chionoecetes bairdi*
SHRIMP	
Pandalid shrimp	*Pandalus spp.*

* Threatened and endangered species are designated by underlining.

SHORELINE DESCRIPTIONS

EXPOSED ROCKY SHORES **ESI = 1A**

DESCRIPTION

- Steep intertidal zone, with very little width
- Regularly exposed to high wave energy, with strong wave reflection patterns
- Sediment accumulations are uncommon and usually ephemeral because waves quickly remove debris slumped from eroding cliffs
- As a result of the high-energy setting, attached organisms are hardy and accustomed to strong hydraulic pressures
- Impermeable substrate with no potential for subsurface penetration
- Seldom found in combination with another shoreline type, however they are often interspersed along the shore with wave-cut platforms and gravel beaches
- Rare in Bristol Bay, but most common along headlands and offshore islands on the southern Alaska Peninsula; occurs along 335 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil is held offshore by waves reflecting off the steep cliffs
- Any oil that is deposited is rapidly removed from exposed faces by wave action
- Most resistant oil remains as a patchy band at or above the high-tide line
- Impacts to intertidal communities are expected to be of a short duration, an exception being where heavy concentrations of a light refined product comes ashore very quickly

RESPONSE CONSIDERATIONS

- Cleanup usually not required
- Access can be difficult and dangerous

EXPOSED WAVE-CUT PLATFORMS IN BEDROCK **ESI = 2A**

DESCRIPTION

- Intertidal zone with a flat rock bench of highly variable width; can be up to several hundred meters wide
- Regular exposure to high wave energy, with strong wave reflection patterns
- May be backed by a steep scarp or low bluff composed of rock, volcanic flows, or glacial till
- Perched beach of boulder-sized sediments may be present at base of the scarp
- Surface is irregular and tidal pools may be present
- Small accumulations of gravel can be found in the tidal pools and crevices in the platform
- May support large populations of encrusting animals and plants, with rich tidal pool communities
- Common along Cape Newenham, Hagemeister Island, Walrus Islands, and throughout the southern Alaska Peninsula; occurs along 483 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate at the high-tide line, where it can penetrate in beach sediments, if present
- Persistence of oiled sediments is usually short-term, except in wave shadows or larger sediment accumulations at the landward edge of the platform, where oil can persist for up to several weeks to months
- Biological impacts can be immediate and severe, particularly if fresh oil slicks cover tidal pool communities

RESPONSE CONSIDERATIONS

- Cleanup is usually not required, because oil is quickly removed by wave action
- Access may be difficult and dangerous
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris in areas of high recreational use or in order to protect a nearshore marine resource, such as marine birds or mammal haulouts

FINE- TO MEDIUM-GRAINED SAND BEACHES **ESI = 3A**

DESCRIPTION

- Generally flat, wide, and hard-packed
- Beachface sediments subject to regular reworking by waves
- Beach fauna vary in type and density but are generally low
- Can be important areas for migrating shorebirds
- Found mostly around the Nushagak Peninsula; occurs along 76 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Light oil accumulations deposited as oily swashes or bands along the upper intertidal zone
- Heavy oil accumulations cover entire beach surface; the oil will be lifted off the lower beach with the rising tide
- Maximum penetration of oil is about 10 cm into fine-grained sand and 15 cm into medium-grained sand
- Burial of oiled layers by clean sand can occur within hours on these beaches depending on the beach cycle, but the maximum burial will typically occur along the upper beach face to depths less than 30 cm
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- The easiest beach type to clean, because hard substrate can support vehicular and foot traffic and depths of oil burial and penetration are minimal
- After all oil has come ashore, cleanup activities should concentrate at first on the removal of oil from the upper swash zone
- Vehicular traffic and walking through oiled areas and dunes should be limited, to prevent contamination of clean areas and disturbance of dune vegetation
- Manual cleanup, rather than road graders and front-end loaders, is advised where feasible to minimize the volume of sand removed from the shore
- Prevent the mixture of oil deeper into the sediments by vehicular and foot traffic

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COARSE-GRAINED SAND BEACHES **ESI = 4**

DESCRIPTION

- Moderate to steep beachface slopes, typically between 5 and 15 degrees in slope
- Sediments are soft, with low trafficability
- Substrate is highly permeable
- The rate of sediment mobility is relatively high, with the vertical accumulation of up to 20 cm of sediments possible within a single tidal cycle
- Beach fauna can vary in type and density; mobile surface, burrowing, and interstitial forms are typical
- Most common shoreline type between Egegik Bay and Port Moller in Bristol Bay; found at river mouths along the southern Alaska Peninsula; occurs along 415 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- During small spills, oil is deposited primarily as a band along the high-tide line
- Under very heavy accumulations, oil may spread across the entire intertidal zone, though it will be lifted off the lower part of the beach during the rising tide
- Penetration up to 25 cm possible
- Burial of oiled layers by clean sand can be rapid, to depths of 1 m or more if the oil comes ashore at the start of a depositional period
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Cleanup can be difficult because equipment tends to grind oil into the sand due to the loosely packed and permeable nature of these coarser-grained sediments; therefore, special care must be exercised at all times while using heavy equipment in order to prevent mixing oil deeper into the beach sediment
- Use of heavy equipment for cleanup may result in the removal of excessive amounts of sand; therefore, where feasible and for smaller amounts of oil, manual cleanup may be desirable
- Vehicular traffic and walking through oiled areas and dunes should be limited, to prevent contamination of clean areas and disturbance of dune vegetation
- Removal of sediment should be limited as much as possible to avoid erosion problems on the beach in the future; however, the common occurrence of multiple buried oil layers in these types of beaches increases the amount of sediment to be handled and disposed of
- Mechanical reworking of the sand into the surf zone (surf washing) may be used under optimal conditions to release the oil without sediment removal

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MIXED SAND AND GRAVEL BEACHES **ESI = 5**

DESCRIPTION

- Moderately sloping beach (8-15 degrees) composed of a mixture of sand and at least 20 percent gravel
- Soft sediments with low trafficability
- Sediment mobility is very high during storms, but considerably less than sand beaches during normal conditions
- Spatial variations in the distribution of grain sizes may be significant, with separate zones of pure sand, pebbles, or cobbles, in addition to the mixed zones
- Substrate has medium-to-high permeability
- Beach fauna can vary in type and density but generally have low densities
- Common in both Bristol Bay and the southern Alaska Peninsula, occurring as extensive beaches fronting cliffs in bedrock and glacial till, as long spits, and as pocket beaches along rocky shores; occur along 1060 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along the high-tide swash line
- During large spills, oil will be spread across the entire intertidal area
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and if the sand fraction exceeds about 40 percent, oil behavior is similar to that described for sand beaches
- Significant amounts of oil can be eroded away during storms
- Burial of oil may be deep (up to 1 m) if oil comes ashore while the beach is recovering from storm conditions
- In sheltered pockets on the beach, such as in the lee of large boulders, pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, and, once formed, these pavements can persist for many years
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in interstitial water

RESPONSE CONSIDERATIONS

- Remove heavy accumulations of pooled oil as quickly as possible
- All oiled debris should be removed
- Vehicular traffic and walking through oiled areas should be limited, to prevent contamination of clean areas
- Sediment removal should be limited as much as possible, because of potential beach erosion problems in the future
- Low-pressure flushing can be used to remove heavy oil where collection of the flushed oil is feasible, but high-pressure flushing should be avoided, because of the potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone for wave reworking (berm relocation) can be effective in areas exposed to significant wave action
- In-place tilling may be used to expose deeply buried oil layers to wave reworking in areas exposed to significant wave action

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GRAVEL BEACHES **ESI = 6A**

DESCRIPTION

- Composed of sediments larger than 2 mm (granules, pebbles, cobbles and boulders)
- Most permeable of all beach sediment types
- Lowest trafficability of all beach types
- Rapid erosion and/or burial of shallow oil possible during storms
- Slope is intermediate to steep (between 10-20 degrees), with multiple, wave-built berms usually forming the upper beach
- Sediment replenishment rates are the lowest of all beach types
- Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile
- Uncommon in Bristol Bay, but present throughout the southern Alaska Peninsula in both exposed and sheltered areas; occur along 465 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Deep penetration and rapid burial of stranded oil is likely; penetration of tens of cm (over 1 m possible) can extend oil to depths below where it cannot be reworked by any natural process except extreme storms
- Therefore, long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves
- Oil may be carried over the normal high-tide line and storm berms during high-water events, where it can pool and persist above the normal zone of wave wash
- In more sheltered areas, formation of asphalt pavements is likely if oil accumulations are heavy

RESPONSE CONSIDERATIONS

- Because of the low trafficability, and the rapid rates of burial and deep penetration of the oil, this is the most difficult of all the beach types to clean

- Heavy accumulations of pooled oil should be removed quickly
- All oiled debris should be removed
- Because of the slow sediment replenishment rates of these beaches, sediment removal should be limited
- Flushing with ambient water can be used to remove some of the oil from the sediments, provided adequate oil recovery is possible
- Mechanical reworking of oiled sediments from the high-tide line to the upper intertidal zone (berm relocation) can be effective in areas regularly exposed to wave activity (as evidenced by storm berms)
- In-place tilling may be used to expose deeply buried oil layers to wave reworking on beaches with high wave activity

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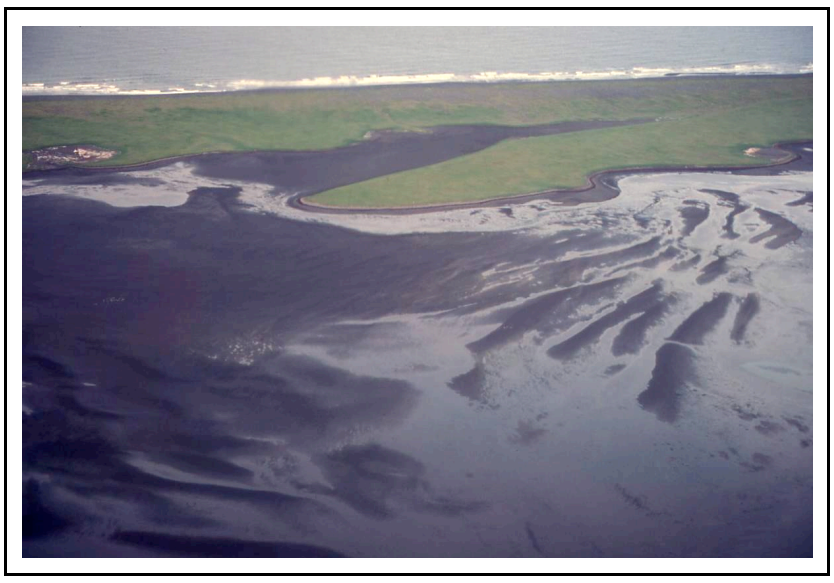
EXPOSED TIDAL FLATS **ESI = 7**

DESCRIPTION

- Flat (less than three degrees) intertidal areas, composed of mostly sand but some mud, that vary in width from a few meters to hundreds of meters
- The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments
- Usually associated with another shoreline type on the landward side of the flat or as isolated flats in the middle of channels
- Sediments usually remain water-saturated, with only the topographically higher ridges drying out during low tide
- Sediments are generally too soft for vehicular traffic
- Biological utilization can be very high, with large numbers of infauna, and heavy use by birds for roosting and foraging
- Extensive flats occur throughout Nushagak, Kvichak, Egegik, and Ugashik Bays and Port Heiden in Bristol Bay; uncommon and associated with lagoons at the head of coastal bay along the southern Alaska Peninsula; occurs along 754 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy



- Oil does not typically penetrate these water-saturated sediments, except on the top of sand bars and into animal burrows if they dry out at low tide; thus, oil penetration is limited to a maximum of a few cm
- Because of the high biological use, impacts can be significant to benthic invertebrates that are smothered or exposed to the water-accommodated fraction of the oil

RESPONSE CONSIDERATIONS

- In most cases, the best response is to let the oil, which is primarily on the surface of the flat, be removed naturally
- Natural removal can be fast in this habitat during open-water months, because of its exposure to waves and tidal currents
- Cleanup is very difficult, because of the potential for mixing the oil deeper into the sediments
- Use of heavy machinery should be restricted in order to prevent contamination of the subsurface sediments, with manual removal being preferred; however, heavy foot traffic can also result in oiling of the deeper sediments

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SHELTERED ROCKY SHORES **ESI = 8A**

DESCRIPTION

- These shorelines consist of steep bedrock shores that are sheltered from exposure to most wave and tidal energy
- The surface can be covered with loose sediment and debris
- Attached biota may be plentiful and varied, especially in lower and mid-intertidal zones
- They are rare in Bristol Bay and uncommon along the southern Alaska Peninsula; occur along 157 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to the rough rocky surface, particularly along the high-tide line, forming a distinct oil band
- Oil can remain for a long time (months to years) because of the low energy setting
- Where surface sediments are abundant, oil will penetrate into the crevices formed by the surface rubble and pool at the contact of the sediments and the rock surface
- Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments
- Impacts to attached organisms can be severe
- Asphalt pavements can form in the cracks and crevices

RESPONSE CONSIDERATIONS

- Cleanup is often required because natural removal is slow
- Water flushing at ambient water temperatures is most effective when the oil is fresh
- All pooled oil and oiled debris should be removed as soon as possible
- Weathered asphalt pavements can be removed manually

PEAT SHORELINES **ESI = 8E**

DESCRIPTION

- Consists of eroding peat scarps at the heads of bays
- They are characterized by a 1-2 meter high scarp and blocks of eroded peat of various sizes in front of the scarp
- The intertidal zone is often very complex, with slumped peat blocks, intermixed with fine- to medium-grained sands
- The intertidal zone of this shoreline type is not particularly important as a biological habitat, although birds do use these areas during migration
- Found only at the heads of bays in Bristol Bay; occurs along 395 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil penetration and persistence are expected to be very low in frozen peat scarps
- Light oil can penetrate the peat surface, especially when dry, resulting in persistent sheens
- Heavy oil does not penetrate peat, even when the peat is dry
- Peat slurries react to oil like loose granular sorbent and will partially contain and prevent the oil from spreading

RESPONSE CONSIDERATIONS

- The peat substrate is soft, thus cleanup will be difficult; trampling is less of concern where peat is frozen or work is conducted from boats

- On these eroding peat scarps, stranded oil will have a low residence time due to the natural erosion rates
- Substrate disruption is of limited concern so long as adjacent wetlands are not disturbed
- Hot-water washing or even low pressure flushing are not appropriate because large quantities of peat could be eroded from the treatment area

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SHELTERED TIDAL FLATS **ESI = 9A**

DESCRIPTION

- Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell
- They are present in calm-water habitats in bays or behind large spits, sheltered from significant wave activity
- They are often backed by salt marshes and peat scarps
- The sediments are very soft and cannot support even light foot traffic in many areas
- There can be large concentrations of invertebrates on and in the sediments
- They are common throughout Bristol Bay but rare along the southern Alaska Peninsula; occur along 836 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and ice cracks or other crevices in muddy sediments

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; deflection or sorbent booms and open-water skimmers should be used
- Cleanup of the flat surface is very difficult because of the soft substrate; many methods may be restricted
- Care should be taken to limit foot traffic during any cleanup operations, to avoid mixing oil into the sediments
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful

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SALT- AND BRACKISH-WATER MARSHES **ESI = 10A**

DESCRIPTION

- Intertidal wetlands consisting of emergent, herbaceous vegetation
- They occur as narrow fringing marshes associated with stream mouths, along tidal creeks, and fronting tidal flats; small pocket marshes in embayments, protected by spits and sand bar features; and broad marsh areas in large protected areas
- Sediments in the substrate range from fine sands to silts and organically rich muds
- Salt marshes common throughout Bristol Bay but uncommon along the southern Alaska Peninsula; occur along 1500 km of shoreline in the mapped areas

PREDICTED OIL BEHAVIOR

- Oil adheres readily to intertidal vegetation
- Oil coating typically takes the form of a band of varying width. The placement of the oil band depends on water level at the time of spilled oil's impact; multiple bands are possible
- Large slicks will persist through multiple tidal cycles and coat vegetation from high tide line to the base of the stem
- If the vegetation is thick, the heaviest oil coating will be restricted to the outer fringe of the marsh. However, the lighter the oil, the further into the marsh it may penetrate
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool in surface depressions or collect in burrows
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to 1 m)

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing care must be taken to prevent transporting oil to sensitive areas down slope or along shore

- Extent of oiling, natural removal processes and rates should be evaluated prior to conducting cleanup
- Cleanup crews and activities must be carefully monitored to avoid unnecessary vegetation damage
- Any cleanup activity must not mix the oil deeper into the sediments; trampling of the roots must be minimized
- Cutting of oiled vegetation should only be considered when other resources present (such as birds) are at great risk from leaving the oiled vegetation in place
- Under light oiling, the best practice is to allow the area time to recover naturally